HOT AND COOL: BRIDGING GAPS IN MASSIVE-STAR EVOLUTION
ASP Conference Series, Vol. 425, © 2010
C. Leitherer, P. D. Bennett, P. W. Morris, and J. Th. van Loon, eds.

Mid-Infrared Circumstellar Shell Sources Discovered with *Spitzer*: An Obscured Population of Massive Stars?

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Abstract. We have discovered a large number of circular and elliptical shells around luminous central sources at 24 μm with the MIPS instrument on board the *Spitzer Space Telescope*. Most of these shells are not visible in the shorter wavelengths bands of IRAC or archival 2MASS and optical images. On the other hand, many of the central stars are detected in the 2MASS catalog, but lack an optical counterpart, indicating that we are dealing with a population of highly obscured objects. Our archival follow-up effort has revealed 90% of these shell sources to be previously unknown.

Motivated by our discovery of an unusual well-defined elliptical shell only visible at 24 μm in some of the first data from the *Spitzer* mission (Morris et al. 2006), we searched the publicly available 24 μm images of the MIPSGAL *Spitzer* Legacy project for similar objects that might shed light on its origin and nature. Our search revealed a surprisingly large number of prominent circumstellar shells with bright central sources. We find 87 such objects in the currently available 200 square degree survey area of the Galactic Plane. Follow-up investigation utilizing the complementary data from the GLIMPSE *Spitzer* Legacy project (3.5–8.0 μm images), as well as 2MASS and the Digitized Sky Survey (DSS) shows that about 65% of these shells are *only* detected at 24 μm. This is somewhat unusual, as we generally expect a strong emission component due to polycyclic aromatic hydrocarbons (PAHs) at 8μm if we are dealing with warm dust continuum emission.

Our archival follow-up effort also showed that 92% of the central sources of the circumstellar shells are detected in the 2MASS J band, but only 32% have USNO B1.0 catalog entries. Since all of our targets have IRAC counterparts, and in many cases are detected even at 24 μm (e.g., Fig. 1), this indicates that we are dealing with a heavily obscured population of sources. A SIMBAD search within $1'$ of the accurate central source coordinates (accurate to $\sim 1''$, obtained from 2MASS) reveals that most of these sources (90%) have not been previously studied. One of the 87 sources is a known planetary nebula (PN) and 6 sources are coincident with known massive stars (OB, Be, emission line stars). The overlap with known objects, while very limited, indicates the type of sources we *expect* to comprise our sample, namely PN and massive stars (i.e., objects with strong winds and/or mass outflows). We are unable to determine the nature of the central sources based solely on archival photometric data since

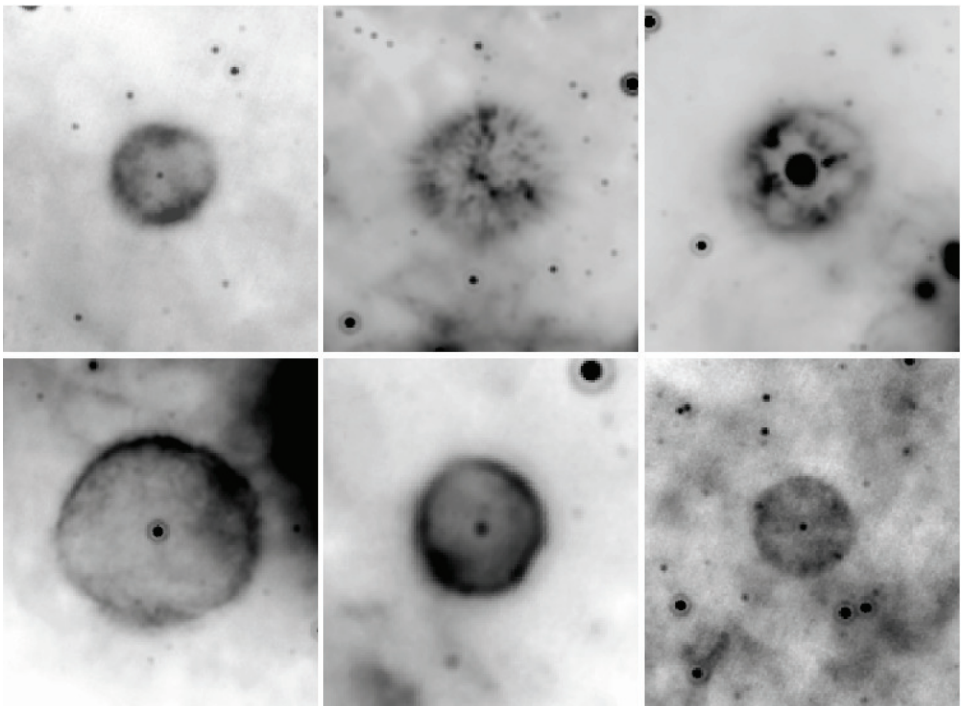

Figure 1. Several examples of the circumstellar shells discovered at 24 μm with the *Spitzer Space Telescope*. The images are cutouts of varying sizes from the MIPSGAL Legacy project.

we do not know the extinction (both intrinsic to the source and between us and the source) or the distance to the shells. We have embarked on a optical and IR spectroscopic follow-up program to identify the nature of the central stars based on characteristic spectral features. Once we have established the nature of the central source, we can estimate the extinction and distance of each source and will be able to derive the physical sizes of the circumstellar shells. The observed apparent shell radii range from 0.2–4′ with an average radius of ∼0.8′. Our sample is large enough that we ultimately aim to perform a statistical comparison between the properties of these mid-IR discovered shell sources and those observed at other wavelengths for the same underlying central source population.

Acknowledgments. This research was carried out, in part, at the Jet Propulsion Laboratory, California Institute of Technology, and was sponsored by the National Aeronautics and Space Administration. We made use of data products from the 2 Micron All Sky Survey and the SIMBAD database operated by CDS, Strasbourg, France.

References

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